UNITED STATES DEPARTMENT OF AGRICULTURE
Bureau of Agricultural Engineering.

SOME ENGINEERING FEATURES INVOLVED IN THE UNITED STATES COTTON GINNING INVESTIGATIONS

by

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INTRODUCTION

Few people have any idea how complex the problems of ginning are, although many realize that cotton ginning constitutes perhaps the most important of the preparatory steps in the marketing of raw cotton. There are intricate and involved difficulties in searching out the truth, because the different types and designs of ginning apparatus are forced to handle a material which may have almost an infinite variation in fibers, seeds, moisture content, and other physical characteristics.

Research is, in a broad sense, an orderly search for and assembly of facts by experimental, analytical, and other methods. Congress recognized that a well-planned and vigorous program in cotton ginning research would render a much-needed service; and to this end established in 1930 the U.S. Cotton Ginning and Fiber Investigations. These were placed under administration of the Secretary of Agriculture, who assigned the engineering responsibilities to the Bureau of Agricultural Engineering and the fiber-quality responsibilities to the Bureau of Agricultural Economics.

The ginning laboratory at Stoneville, Miss., was constructed by the engineers during the latter part of 1930, on a tract deeded to the United States by the State of Mississippi. The ginning laboratory building is a 3-story structure of steel, hollow tile, and cement stucco, containing well-equipped shops and a wide variety of drying, cleaning, conditioning, and ginning apparatus. Adjacent to the ginning laboratory, in 1934, the engineers constructed a second 3-story building for fiber laboratories. A cotton house and an all-steel storage building afford facilities for storing seed cotton not ginned immediately upon delivery and samples derived from the tests. Other structures such as sun drier, delinting house, artesian well, incinerator, and superintendent's dwelling have been provided.

The experimental machinery in the ginning laboratory comprises a wide variety of different commercial saw and roller gin stands, air-line cleaners, out-of-the-air cleaners, unit extractor-feeders, cleaning feeders, separators, driers, linter, condensers, press and other auxiliary apparatus. The fiber laboratory building houses length-array, color, moisture microscopic, classing, and other laboratories fully equipped with apparatus for making tests on samples of seed cotton, ginned lint, and by-products.

The personnel of the ginning laboratory comprises the engineer in charge and two engineer assistants besides the necessary laboratory and clerical assistants, mechanics and unskilled labor. The staff of the fiber laboratories associated with the ginning studies comprises, at Stoneville and at Washington, the technologist in charge, five technological assistants, one classing specialist, and a number of laboratory and clerical assistants and unskilled laborers.

METHOD OF APPROACH TO COTTON GINNING PROBLEMS

For many years, a scientific approach to the problems of ginning was impeded both by lack of facilities for varying sufficiently and for controlling the conditions of ginning, and by lack of methods of measuring the effect upon the ginned fiber of variations in seed cotton and in the ginning processes. The establishment of a ginning laboratory especially designed and equipped for experimental work has removed the first of these obstacles, and recent developments in fiber analysis have in part removed the second.

The method employed in the ginning studies is both experimental and analytical. The equipment is designed to permit the variation over a wide range and the control within narrow limits for each of the major variables in machine design, organization and operation, thus enabling observations to be made of the effect of varying any particular factor. These mechanical variations are for the most part susceptible of precise mathematical expression. During the tests, engineering observations are recorded relative to psychrometric and thermo-pneumatic conditions; power consumption; speeds; weights of trash, motes, lint and seed; mechanical performance of machines; rates of ginning in terms of pounds of ginned lint per saw per hour; and other features.

The program of ginning tests has been based upon the plan of first determining each separate effect produced by the driers, cleaners, extractors, and cleaning feeders upon the seed cotton before it reaches the gin stands. This has required thousands of tests in which the cotton progressed from machine to machine both according to and differing widely from the sequences and combinations in commercial gins. This procedure was adopted not only to obtain information on the factors concerned but also to avoid erroneously attributing such effects to the gin stands proper. A wide range of drier temperatures, cleaner and saw speeds, and seed-roll densities have been employed.

The fields of engineering and fiber work already have unfolded to a point where a number of very specialized problems are visible whose solutions require vigorous and uninterrupted study by persons with highly specialized qualifications. The limiting factor in carrying the development of adequate knowledge forward to logical completion within a reasonable time is largely a matter of personnel and facilities.

THE RESPONSIBILITY OF THE COTTON FARMER

The cotton farmer is, in a very large measure, responsible for the condition in which the seed cotton comes to the gin. He is as fully obligated to deliver good seed cotton to the ginner as he is to exert every effort towards producing a good crop for the harvest. He can neither expect the ginner to be a magician, who by some mysterious words or a wave of the hand can cure a load of rough cotton, nor evade the fact that indifference to ginning and ignorance of its processes are affecting his pocketbook. Somehow, many farmers think that the market will absorb rough or damp lint without any reduction in price. This is erroneous, and the farmer is learning that consumers will not knowingly buy moisture, dirt, waste, or foreign matter at cotton prices. No matter how involved may be the present system of growing, marketing and utilization, the effects of ginning will sooner or later come right back home to the cotton farmer.

The cotton farmer, therefore, must not only assume responsibility for a reasonable share of the complaints, but must also understand that any effort on his part to improve the marketability of his product will eventually become a profitable service to himself. Heretofore the cotton farmer has contributed to haphazard ginning because the processes and results were not clearly understood. This in turn has led to inadequate gins, cut-throat competition, and doubtful practices - all of which ultimately increase the expense of the cotton farmer.

A century of experience should impress upon our cotton farmers at least one vital fact; namely, that in the brief period of time required for ginning a bale of cotton is established once and for all its highest marketable and utilization value. The bale may subsequently become worse from various causes, but it has never been known to become better. The farmer cannot shirk his responsibility in the matter of what he brings to the gin, though wind, weather, and other uncontrollable elements may unavoidably damage the raw product. To the farmer, then, belongs an unquestionable responsibility to cooperate with and obtain from the ginner only the highest quality of service. If the ginner renders such a service, he is entitled to payment sufficiently profitable to warrant him continuing in the business.

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DRYING AND CONDITIONING

The ginning of damp, heavy, green, or wet seed cotton may produce severe losses to the cotton farmer and at the same time prevent profitable cooperation of the ginning establishment. Between 1926 and 1928 the engineers of the Division of Agricultural Engineering developed and patented a process for drying seed cotton that has come to be known as the "Government Process". This process is feasible for use at public gins, and may be used with any of several types of driers to provide a simple and dependable installation having sufficient capacity to supply as many as five 80-saw gin stands from one drier. Figure 1 shows the principal features of the vertical cotton drier developed by the U.S. Cotton Ginning and Fiber Investigations, which has proved to be practical in all respects.

As will be pointed out in more detail by Mr. Gerdes in his companion paper, our research has proved for the first time the definite facts concerning the extent of the major influence which moisture content in seed cotton exerts upon the quality of the ginned lint. Cotton ginning and the quality of ginned lint have thus been proved to be vitally affected by a need for artificial drying or other beneficial conditioning, and consequent numerous publications and official releases 1/ have been made upon this subject in an effort to acquaint ginners and the public with the importance of having the seed cotton dry when it is to be cleaned, extracted, or ginned.

Since the Government Process for drying seed cotton is now well-known through the drying of approximately 250,000 bales in Texas and other States, I need only briefly repeat what the process requires; namely, (a) from 40 to 100 cubic feet of heated air for each pound of damp seed cotton; (b) a period of exposure from 15 seconds to 3 minutes, depending upon the kind of drier used; and (c) a preferable temperature

1/ (1) U.S.D.A. Misc. Pub. 149 "The Vertical Seed-Cotton Drier", by Chas. A. Bennett, Bureau of Agricultural Engineering.
(2) Yearbook of Agriculture, 1932; "Cotton Quality Affected in Ginning Process by Moisture in Seed-Cotton", by F. L. Gerdes, Bureau of Agricultural Economics.
(3) Yearbook of Agriculture, 1932; "Seed-Cotton Drying proves Profitable; Two Types of Driers Used", by Chas. A. Bennett.
(4) Acco Press, July, 1930; "Drying of Seed Cotton in Process of Ginning", by Chas. A. Bennett.
(5) Cotton & Cotton Oil News, April 2, 1932; "Better Ginning and Improved Preparation", by Chas. A. Bennett.
(6) Agricultural Engineering, March, 1933; "Results of Recent Cotton Ginning Investigations", by Chas. A. Bennett.
(7) American Ginner & Cotton Oil Miller, Sept., 1933; "Research in Mechanical Phases of Cotton Ginning", by Chas. A. Bennett.
(8) American Ginner & Cotton Oil Miller, Oct., 1933; "Research on Cotton Fiber Quality in Relation to Ginning," by F.L. Gerdes.
(9) U.S. Bureau of Agricultural Engineering (Mimeo.),"Some Mechanical Elements Involved in Good Ginning." by Chas.A.Bennett.
(10)U.S. Bureau of Agricultural Economics (Mimeo),"Some Cotton Quality Elements as Influenced by Ginning", by F.L.Gerdes.

of 150° to 160° F. for prime cottons, and higher temperatures up to 200° for late, rain-soaked cottons.

Figure 1 outlines the vertical drier and four methods of feeding it. Home-made driers of the Government design have generally proved serviceable, although it is recommended that factory-built driers be used wherever possible, because builders of home-made driers are prone to include ideas of their own in the construction and by departure from the Government instructions often find themselves facing unforeseen difficulties. All this is eliminated by the use of factory-built units.

Properly conditioned seed cotton, whether dried artificially or by some other means such as sun drying or storing, yields itself much more readily to advantageous handling through the cleaning, extracting and ginning processes.

In regard to power requirements in ginning damp cotton, our tests showed that the damp or wet seed cotton required from 14 to 23 percent more power per gin stand than for the same cottons artificially dried. In addition to this feature, I wish to emphasize the importance to profitable operations obtained with dry cotton, such as continuity of ginning without interruption from chokages and breakdowns, ability to gin on cloudy or rainy days at normal speeds, ability to save a farmer's damp cotton, by drying, from such deteriorating effects as souring, sweating, discoloration, etc. As Mr. Gerdes will point out in his discussion, there is definitely an additional dollars-and-cents improvement in each dried bale. Although operating cost data remain to be compiled, our own experiences have been that we can dry 25 bales of seed cotton with one ton of coal, and that the cost of drying seed cotton is less than the resulting increase in monetary value of the lint.

CLEANING AND EXTRACTING

The American manufacturers have made noticeable improvements in the construction of cleaning and extracting machinery during the past four years. All-metal construction is now standard practice; improved forms of cylinders have been adapted to regional requirements; and the mechanical aspects of drives and installation are excellent.

The ginner is therefore now faced with the problem as to what combination of equipment will serve his community and at the same time not deprive him of profit through costs for extra power or through interest and depreciation charges on too heavy an investment. However, we know that the ginner is not damaging the staple length of the product so much as he has been accused of; but an excessive amount of cleaning and extracting machinery still cannot accomplish from roughly harvested cotton what simpler machinery would do from clean, hand-picked cotton.

It is probable that some ginners are now so overequipped with machinery that they are, so to speak, hauling 1-ton loads in a 5-ton truck; and we know that others, who are underequipped, are vitally concerned with every dollar which must be put into new machinery.

From power readings taken with our electrical instruments during ginning tests, it now appears that the same amount of electrical energy or kilowatt-hours is required to gin a bale of cotton with a loose roll as with a tight one. The longer time element for loose rolls is offset by the smaller requirement for power, while the tight rolls require much more power but for a shorter time. Since this is proving to be the case, we are interested in finding how much energy can be profitably allotted to cleaning and extracting, so as to produce the best sample without excessive power or machinery.

We believe that each ginner should study his own equipment with this in mind, to ascertain that he is getting the full advantage of every unit by means of correct speeds, adjustments, feeds and other items. It is not advisable to buy additional machinery until one knows where the weakness may lie in his existing outfit.

In our preliminary tests, we obtained an indication that the air-line cleaners were performing differently per cylinder than similar out-of-the-air units. During the coming season we are planning to study their relative merits, by testing two 6-cylinder machines of the same make side by side, one being arranged for airline operation and the other as a conventional cleaner.

The laboratory work will also include testing various forms of screens and cylinders, to whatever extent may be possible during the major tests upon the gin stands which we are now undertaking. Parallel to these tests will be others on fans - a subject which is vital to power saving as well as to good operation. Fans are at best air-pumps of low efficiency. In many gins exhausters are used where blowers belong, and vice versa, thus still further affecting the efficiency. Compounded with such installations one also finds seed-blowing instead of mechanical conveying equipment, using from five to ten times as much power as is warranted. A ginner can lose money through air-pipes almost as easily as through holes in his pockets. Many fans now using 19 or 20 horsepower to run at 1,800 r.p.m. will sooner or later be replaced with higher efficiency fans which at 1,400 r.p.m. will deliver the same air with only 12 horsepower. We are testing just such equipment at Stoneville, and expect to influence ginners to consider the selection and use of more efficient fans in their cotton ginning plants.

GIN STAND OPERATION

During hundreds of tests we have been unable to obtain quality and quantity ginning at the same time. If quality is to be preserved, one must to some extent sacrifice quantity or pounds ginned per hour. We have so thoroughly proved that heavy rates of feeding with their attendant tight seed rolls make a poor sample, as compared to moderate

feeds and loose seed rolls, that it seems as if we are repeating an old story. But the importance of the matter is vital to maintaining or improving the quality of our American cotton crop. No one denies that one may gin faster with a tight seed roll but fast ginning is objectionable to the farmer and increases power requirements almost 50 percent. It is therefore up to the ginner to at least divide his interest between quantity and quality in as rational a manner as possible.

In figure 2 we have marked the settings which must be checked to preserve the right relationships between gin saws and gin ribs, as a primary step toward obtaining quality. These are very important and each ginner should see that these distances are in accordance with factory instructions. A small difference may needlessly reduce the value of the bale by a dollar or more, and if it becomes known a loss of customers may follow.

As we have stated in several published articles, brush-tip speeds and airblast nozzle pressures should also be frequently checked by the ginner. We endeavor to keep our brushes at the speed which gives the bristle tips a linear velocity of 6,666 feet per minute, and our airblast nozzles at settings and pressures dictated by regional needs. In the December, 1933, issue of The Cotton Ginners' Journal was published a description of how to make a home-made airblast gauge, and we hope that every progressive ginner in this State now has one. In the November, 1934, issue recommendations were given for the care of gins at the close of the season.

In operating our gin stands, we have been interested to find that the speed with which our seed rolls turn is virtually fixed for each density at which the roll is maintained. Thus on one gin, a loose roll turned at 84 r.p.m. and a tight roll at 116 r.p.m. regardless of variations in the saw speeds from 300 to 800 r.p.m.

Our analyses of several thousand tests have indicated that saw-speed variation within plus or minus 100 r.p.m. of the manufacturer's recommended speed is secondary in effects, while seed-roll density is of primary importance. The saw-speed variations seldom produced significant changes, but varying the seed-roll density brought about noticeable and important changes in the samples.

Our tests are showing also that loose seed rolls will give as satisfactory a turnout as tight rolls, although for many years some ginners felt that well-cleaned seed could only be obtained with a tight seed roll.

GIN SAWS

This brings us to a subject that is vital in the operation of saw gins and to a consideration of the ginning teeth and ribs. In figure 2 are indicated the settings that must be verified in order to assure correct mechanical relationships between the saws and ribs.

In figure 3 are indicated the general shapes and characteristics of gin-saw teeth now in use. The subject of tooth design and construction

is so complicated and technical that I shall not endeavor to discuss the engineering aspects at this time. However, it may be said that there are very definite precautions which must be taken if a ginner is to obtain the best results. First, the gin saws must retain the factory condition of sharpness, pitch, and so forth; and the ribs as well as the saws must be in good condition and spacing. Second, the angle of advance of the teeth must be preserved, a matter which many ginners do not observe when they do their own sharpening.

In this regard, let me state that we do not advocate the sharpening of gin saws at the gin in those cases where the manufacturers have issued instructions to the effect that their guarantees and service are voided if sharpening is not done at the factory. On the other hand, many ginners are compelled to do their own sharpening, and where machines are available they should only be used by skilled operators.

Sharp teeth whose points pass through the ribs slightly ahead of the throats have, in our experiments, produced a greater turnout than those which leaned backward or had a negative pitch. The amount to which the sides of the teeth may be tapered is somewhat problematical, and probably depends upon the kind of cottons to be handled, but from one-third to two-thirds of the saw-disk thickness appears to be satisfactory. As you know from experience, when the tooth has a bright or "bald"spot at its ginning tip, its capacity and ability to clean seed are lowered.

Factory shapes and pitches must be preserved for best results; and although no one now advocates the use of a heavy roach, the straight teeth or modified roach shapes should not be allowed to deteriorate into faulty or inferior shapes.

Saw sharpening machines should not be operated upon uneven or rough floors, because there is a hazard that such irregularities will be reproduced in the saws by throwing the files out of adjustment. Further, attempts to train a saw cylinder should not be permitted on the part of a novice or an unskilled workman.

There have been great strides in improvement of saw sharpening machinery during the past five years, but no machine is fully automatic and good common sense is necessary in giving them an opportunity to render the service for which they are built.

Ribs are the team-mates of the saws in ginning. We do not look with favor upon ribs that are repaired by hand methods at the gins or in poorly equipped shops. Repairs by the recently developed method of welding, for instance, can only be approved when they are made under precision conditions - where the built-up rib can be ground to factory dimensions by accurate means that are not affected by faulty eyesight or jumpy nerves, and where the final finish will produce a smooth, tough surface and edge.

Thus far in our tests, when using either poor saws or poor ribs we have noted decreased turnout. Poor saws gin slowly and do not clean the seed well, and poor ribs also contribute to less turnout and to impairment of the sample in ways with which you are familiar. However, changes in saw speed with poor saws do not appear to have any more effect than they do with good saws, showing that saw speed is a secondary consideration regardless of the condition of the saws and should not be changed from the rate for which the gin is designed.

In our tests with poor saws in comparison to good saws, we found that the poor saws reduced our out-turn as much as 10 pounds of lint per bale, and in ginning time took from 20 percent longer for short cottons up to 50 percent longer for staple cottons. Mr. Gerdes will give you the facts regarding the quality of the inferior samples produced from poor saws. The importance of all of these items when taken together will thus be plain to every one, and calls for care in preserving the saws in factory condition and the ribs in first-class shape.

CONCLUSIONS

Several manuscripts are now being prepared for publication by the U.S. Department of Agriculture relating to many of the subjects which I have discussed in this paper and which Mr. Gerdes will discuss in his paper.

The cotton ginning and fiber investigations have definitely proved, by thousands of laboratory tests and by the drying at commercial gins of approximately one-quarter of a million bales of cotton during the past four years, that the Government Process and use of a cotton drier in certain regions of the South are of benefit to the cotton farmer by improving the sample materially, and to the ginner by eliminating chokages and repairs, by decreasing power requirements, and by generally improving the germinating qualities of the seed.

In its cotton ginning research, the Department of Agriculture has also definitely established the improvement which ginning with a loose seed roll produces, affording the cotton farmers superior smoothness of sample without loss of staple length or turnout and giving the ginner better operating conditions and machinery performance.

It has been proved by many scientific tests that seed-roll density is of primary importance, while speed of the gin saws is secondary; that fast ginning is not so much a matter of saw speeds, within reasonable variations from the manufacturer's recommendations, as of how fast the seed cotton is fed into the roll box.

Tight seed rolls require approximately 50 percent more power for operating the gin stands than do loose seed rolls, by actual tests with electrical instruments, while changes in saw speed make a much smaller difference in power requirements.

By the use of good saws instead of poor saws, the ginner can secure a higher lint turnout in a much shorter time, obtaining as much as 10 pounds more of lint per bale with good saws and do it in from 20 to 50 percent less time than with poor saws.

The necessity for correct relationship of saws and ribs has been stressed by the ginning and fiber laboratories, and general requirements for tooth shape and practical procedure for sharpening have been outlined in the light of our experiences to date. Instructions of the ginning manufacturers and of the makers of saw sharpening machines should be carefully followed in order to preserve the factory condition of the saws. Do not allow novices or inexperienced itinerant repair men to tamper with your saws or ribs. If rib repairs are necessary, they should be made in well-equipped shops having means for precision grinding and machine work.

And finally, since the ginning machinery of today does not yield itself to quality and quantity at one and the same time, it is imperative that quality be made the principal objective - because that objective is a sound and sensible basis upon which we may hope to strengthen the position of American cotton in both foreign and domestic markets and thereby improve the position of American cotton farmers and ginners.

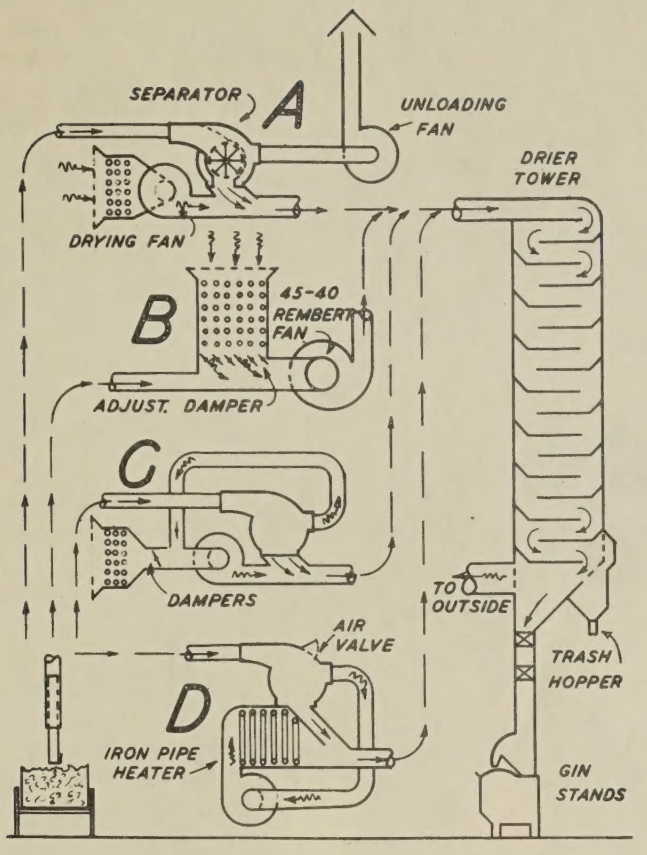

Figure 1.- Approved methods for feeding the Government design vertical drier.

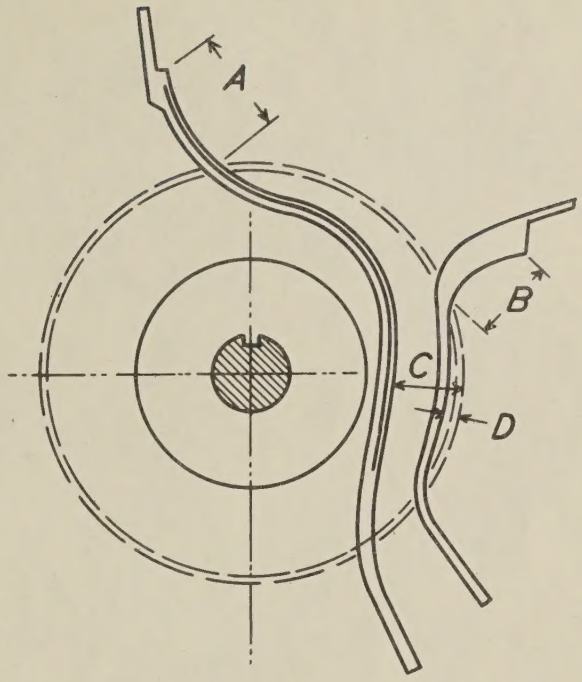

Figure 2.- Diagram of gin saw and rib relations to be checked in preserving correct or factory settings.

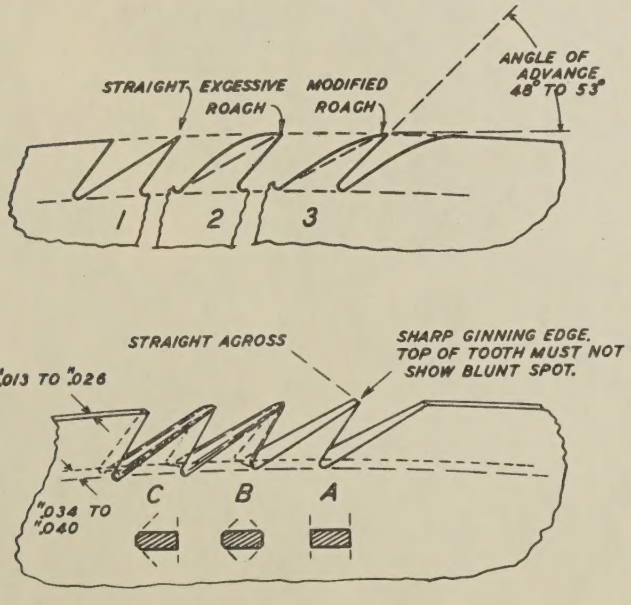

Figure 3.- General features of gin saw teeth.
(Upper view) Shapes of teeth: 1, straight, 2, excessive roach; 3, modified roach.
(Lower view) Finished forms of teeth in general use: A, pyramid or plain tooth; B, round corner tooth; C, round back tooth.